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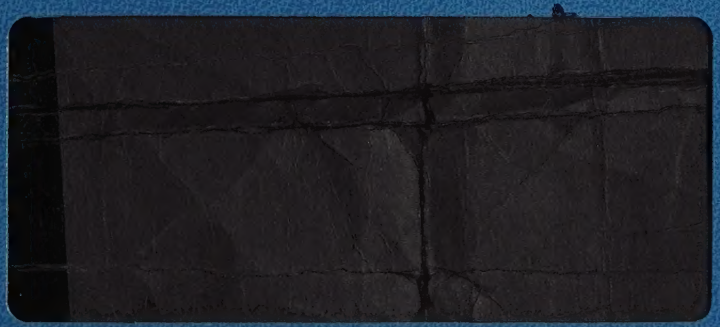

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Model 3102 #401
MILLIDAPTER

OPERATING and SERVICE MANUAL

R. H. DEMPSEY MANUFACTURING COMPANY
A Division of NEURODYNE-DEMPSEY, INC., 525 Fairview Dr., P O Box 1925, Carson City, NV 89701

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table of contents

Section		Page
I	***GENERAL INFORMATION***	1-1
1.1	Introduction	1-1
1.3	Description	1-1
1.7	Accessories	1-1
II	***INSTALLATION***	2-1
2.1	Introduction	2-1
2.3	Incoming Inspection	2-1
2.6	Claims	2-1
2.8	Repackaging for Shipment	2-1
2.11	Preparation for Use	2-2
III	***OPERATION***	3-1
3.1	Introduction	3-1
3.3	Resistance Measurements	3-1
3.10	Equipotential Grounding Systems	3-1
3.12	Voltage Measurements	3-3

contents (cont)

Section		Page
IV	PRINCIPLES OF OPERATION	4-1
4.1	General	4-1
4.3	General Theory	4-1
4.12	Detailed Circuit Description	4-2
4.17	Theory of the Four-Terminal Resistance Measurement	4-7
V	PERFORMANCE CHECK	5-1
5.1	General	5-1
5.4	Performance Check	5-1
5.9	Source Voltage	5-1
5.11	Source Current	5-1
VI	REPLACEABLE PARTS	6-1
6.1	Introduction	6-1
6.4	Ordering Information	6-1

list of illustrations

Figure	*Title*	*Page*
1.1	Model 3102, Millidapter	1-0
3.1	Front and Back Controls and Functions	3-2
3.2	Power Cord Ground Lead Resistance	3-4
3.3	Equipotential Ground Resistance	3-5
4.1	Switching Circuit for Voltage Conversion	4-3
4.2	Self-Oscillating Switching Regulator	4-4
4.3	Block Diagram	4-5
4.4	Diagram of Four-Terminal Resistance Measurement	4-6
5-1	Main PC Board Component Location	5-2
5-2	Schematic of Current Source	5-3

list of tables

Table	*Title*	*Page*
1-1	Specifications	1-2
6-1	Replaceable Parts	6-2

MILLIDAPTER
MODEL 3102
INSTRUCTIONS: Plug 3102 into receptacle on Model 431. Lift ground strap on external meter terminals and plug the attached cord into the red and black jacks. Set function switch on Model 431 to external current. Connect the desired test cable to the test jacks on rear of 3102 and to equipment under test. Set switch to millivolts or milliohms, read value on top scale of 431 meter. Full scale equals 0-10, 0-100, and 0-1000 millivolts or milliohms.
MILLI-
VOLTS
MILLI-
OHMS

FIGURE 1.1 MODEL 3102 MILLIDAPTER

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general information

1.1 ■ INTRODUCTION

1.2 This manual contains operating and maintenance instructions for the Model 3102 Millidapter.

1.3 ■ DESCRIPTION

The Millidapter is an accessory to the 431 Safety Analyzer which will allow the precision measurement of low voltage and resistance. Its purpose is to accurately determine the resistance in the ground path from an instrument to the ground pin on its power plug. It can also be used to determine the point to point ground path resistance between any two selected points in a patient's environment. The Millidapter has an added function which allows accurate measurement of small voltages (down to 0.2 millivolts) between any two points in the patient's environment.

1.5 The Millidapter is an automatically powered constant current source with a function selector to provide four terminal resistance measurements of very high accuracy (refer to Figure 1.1). It is designed for ease of operation requiring minimal setup to accomplish precision measurements.

1.6 The theoretical basis for the four terminal measurement is described in Section 4.

1.7 ■ ACCESSORIES

1.8 Accessories furnished with the Model 3102 include one test probe, Part No. T3115-15, and one set of test leads, Part No. T3114-6.

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Table 1-1 SPECIFICATIONS

Ranges:	0-10, 10-100, 100-1000 milliohms/millivolts
Input Resistance:	500 Ω on milliohms 1000 Ω on millivolts
Test current:	0.5 amp D.C., 2 volts max.
Accuracy,	
test current:	0.5%
overall:	2%
Power Source:	Utilizes power from test receptacle on 431
Weight:	1 lb approx.
Size:	2½ x 2¾ x 3¾

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installation

2.1 ■ INTRODUCTION

2.2 This section contains information for making a visual and electrical inspection of the instrument, processing a claim, repackaging for shipment, and installation procedures.

2.3 ■ INCOMING INSPECTION

2.4 Check the shipping carton for damage immediately after receipt. If damage is found, ask the carrier's agent to be present when the instrument is unpacked. Inspect the Model 3102 Millidapter for physical damage, such as bent or broken parts and dents or scratches.

2.5 Next, check the electrical performance as soon as possible (see Section V, Performance Check). This check will indicate whether or not the instrument will operate within the specifications listed in Table 1-1. If a defect is discovered, refer to the claim procedure in this section.

2.6 ■ CLAIMS

2.7 If physical damage is found or if operation is not within specifications when the instrument is received, notify the carrier immediately. If R. H. Dempsey Mfg. Company or their factory representative is notified, arrangements will be made for the repair or replacement of the instrument without waiting for the carrier to settle the claim.

2.8 ■ REPACKAGING FOR SHIPMENT

2.9 When shipping an instrument to R. H. Dempsey Mfg. Company, attach a tag describing required services and include model number, serial number, and return address.

2.10 Use the original carton and packaging materiel for reshipment. If they are not available,

use the following as a guide for repackaging an instrument for shipment.

a) Use a double-walled carton of sufficient test strength for the weight to be shipped.
b) Use heavy paper or cardboard to protect all instrument surfaces. Use a nonabrasive material around all projecting parts.
c) Use at least four inches of tightly packed, industry-approved, shock-absorbing material around the instrument.
d) Use a heavy-duty shipping tape for securing the outside of the carton.

2.11 ■ PREPARATION FOR USE

2.12 The Model 3102 is ready for use as shipped from the factory. The unit is powered by the Model 431 Safety Analyzer and needs only to be plugged into the test receptacle on the Model 431. There is no power switch since power is supplied automatically.

2.13 Lift the ground strap on the External Meter terminals and plug the attached cord into the red and black jacks, matching the colors.

2.14 The function switch should be in the MILLI-VOLTS position except when resistance measurements are actually being made.

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operation

3.1 ■ INTRODUCTION

3.2 The Model 3102 Millidapter extends the range of the Model 431 Safety Analyzer into the milliohm region. It also corrects the scale factor on the 431 to allow millivolt readings to be taken off the microamp ranges. Each of these measurements will be discussed separately.

3.3 ■ RESISTANCE MEASUREMENTS

3.4 SET UP

3.5 Set the Model 431 Function Switch to EXTERNAL TESTS—CURRENT.

3.6 POWER CORD GROUND LEAD RESISTANCE

3.7 Plug the power cord to be tested into the receptacle on top of the Model 3102. Set the Function Switch to MILLIOHMS. Refer to Figure 3.1. Connect the T3114-6 test lead to the back of the Millidapter and connect the alligator clips to the case of the equipment connected to the power cord under test. Refer to Figures 3.1, 3.2. Read the resistance of the power cord-case ground pathway directly on the 431 meter. Use the current scale and read milliohms in place of microamperes.

3.8 If the power cord under test has a molded plug on both ends, it can be tested independently of any other equipment. Use the ground probe T3115-15 in place of the T3114-6 cable and insert the probe tip into the ground receptacle on the female end of the cord.

3.9 Record the reading on the data sheet.

3.10 ■ EQUIPOTENTIAL GROUNDING SYSTEMS

3.11 Ground resistance measurements can be made between any two receptacles within reach of the combined lengths of the 10-foot power cord to the Model 431 and the 15-foot T3114-15 test probe (refer to Fig. 3.3). Plug the Model 431 into one of the wall receptacles (A). Plug the twin connector of the T3115-15 test probe into the back of the 3102 and plug the probe itself into the ground pin socket of the other wall

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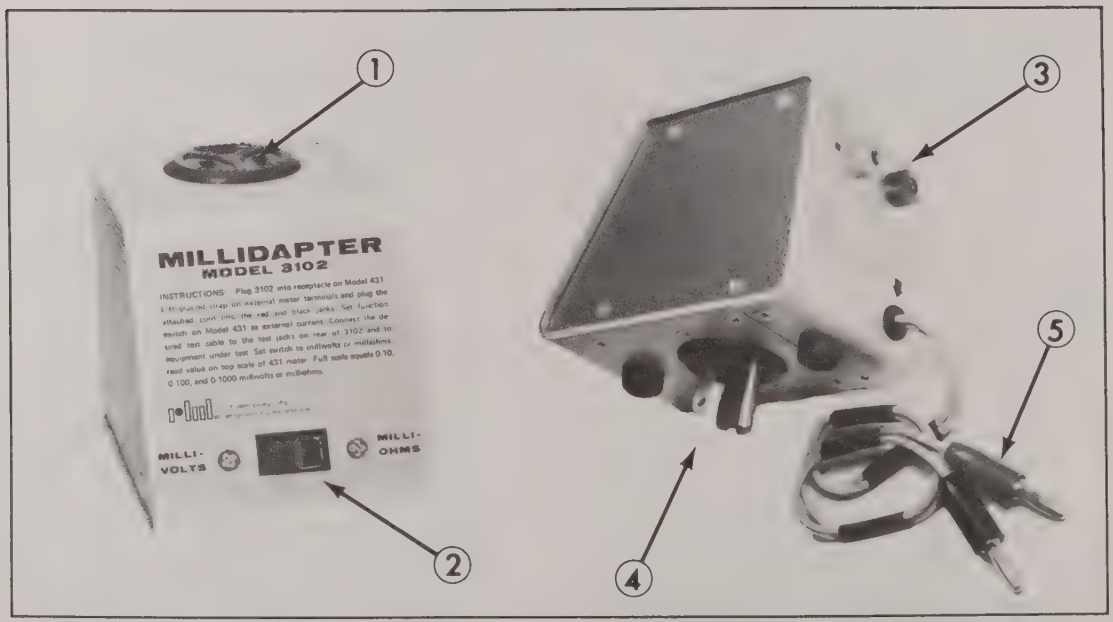

FIGURE 3.1 FRONT & BACK CONTROLS & FUNCTIONS

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1	Receptacle for Instrument Under Test
2	Function switch
3	Connections for probe or test cable
4	Connections to Model 431 for power
5	Connections to input of Model 431 measuring circuits

FIGURE 3.1 CONTROL FUNCTIONS, cont.

receptacle (B).

Push the D.C. only switch on the Model 431 to eliminate the effect of any A.C. that might be present.

The resistance that is measured is the resistance between the case of the Model 431 plugged into wall receptacle (A) and the wall receptacle (B) that the ground probe is plugged into. To get the resistance between the receptacles subtract 0.06 ohms, the resistance of the 10 ft. power cord of the Model 431. The resistance between the two receptacles should be below 0.1 ohm for an equipotential grounding system.

3.12 ■ VOLTAGE MEASUREMENTS

3.13 The Millidapter will also measure the voltage in millivolts between two ground points. Proceed as in measuring for an equipotential ground system except move the switch on the Model 3102 to Millivolts.

Connect the ground probe tip to surface under investigation. Read the voltage difference between the case of the Model 431 and the probe tip on the current ranges, 0-10, 10-100, and 100-1000 millivolts.

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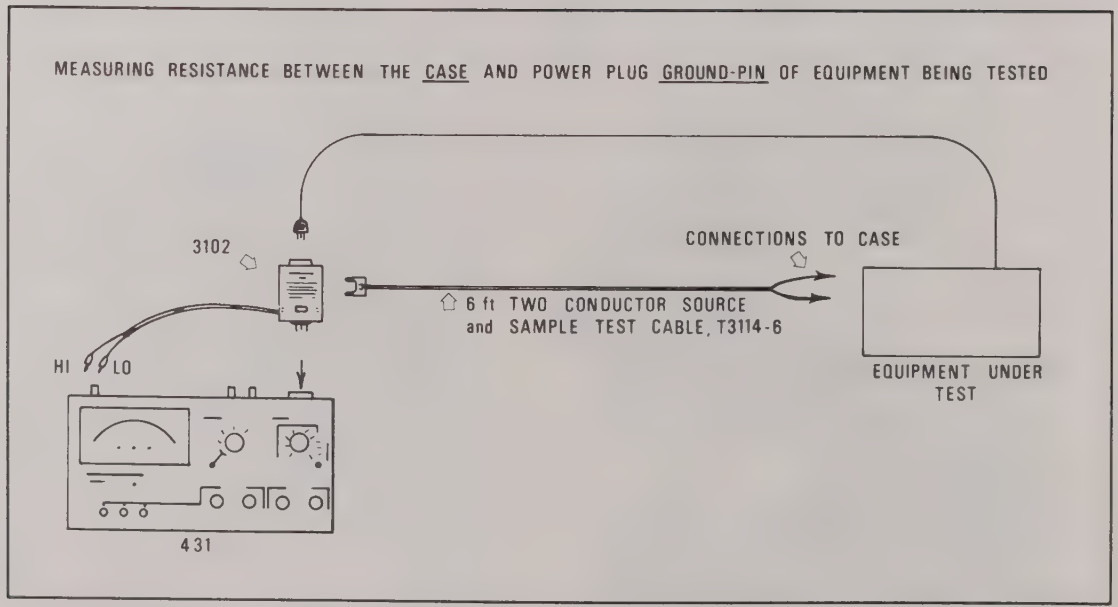

FIGURE 3.2 POWER CORD GROUND LEAD RESISTANCE

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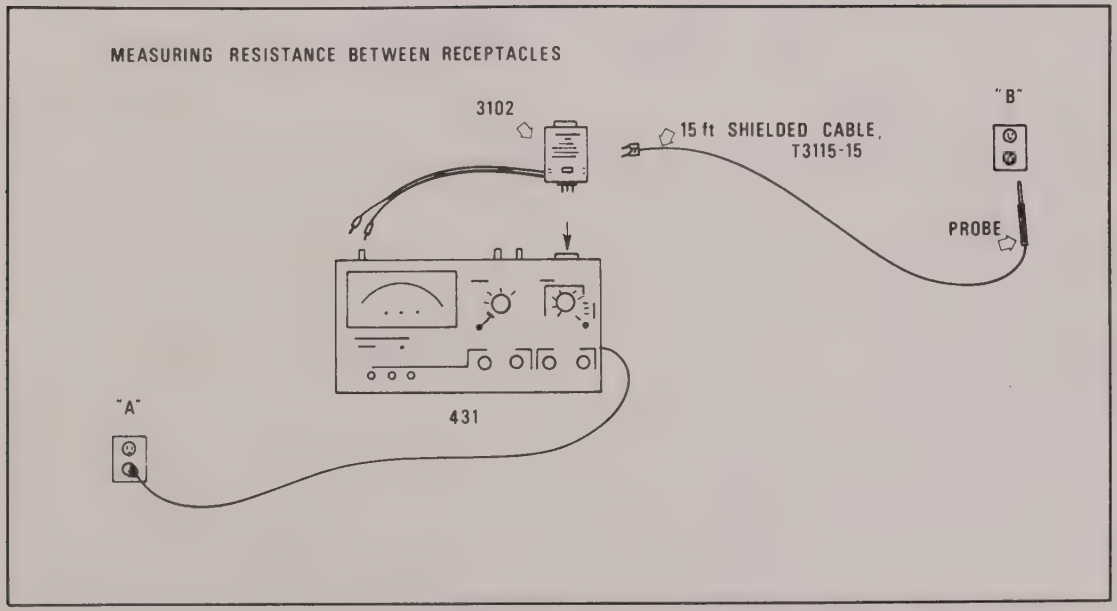

FIGURE 3.3 EQUIPOTENTIAL GROUND RESISTANCE

notes

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principles of operation

4.1 ■ GENERAL

4.2 This section contains an overall description and some detailed explanations of circuit theory. Refer to the overall block diagram and figures in this section and the schematics in Section V while reading the text.

4.3 ■ GENERAL THEORY

4.4 Following is an overall explanation of circuit operation based on the block diagram in Figure 4.3 This data is provided for a basic understanding of the instrument.

4.5 All power for the Millidapter is derived from the Model 431 Safety Analyzer. No other power source is needed.

4.6 The ½ AMP DC precision current source generated within the Millidapter provides the test current used for the four-terminal milliohm measurement. This current source uses a switching mode regulator for greater efficiency.

4.7 The switch selects MILLIOHM or MILLIVOLT measurements.

4.8 The circuitry consists of 1) function selector switch; 2) constant current source; and 3) appropriate connectors.

4.9 The function selector switch connects the current source to connector 4 (BLUE) and shorts out R9 when in the MILLIOHM position. In the MILLIVOLT position it disconnects the current source from the probe and puts R9 (a calibrating resistor) in series with the probe for voltage measurements.

4.10 The constant current source provides a precision ½ ampere DC for milliohm four terminal resistance measurements.

4.11 The receptacle on top of the Millidapter (2) is a modified receptacle (patent pending) which makes

two contacts to the ground pin (see Fig. 5.2). This makes two of the contacts required for the four terminal resistance measurements.

4.12 ■ DETAILED CIRCUIT DESCRIPTION

4.13 The switching mode regulator provides a high efficiency method of providing good regulation at high current levels. The method by which a switching regulator produces a voltage conversion with high efficiency can be explained with the aid of Figure 4.1. Q1 is a switch transistor which is turned on and off by a pulse waveform with a given duty cycle, and D1 is a catch diode which provides a continuous path for the inductor current when Q1 turns off. The voltage waveform on the collector of Q1 will be as shown in Figure 4.1. The output of the LC filter will be the average value of the switched waveform, V1. If the voltage drops across the transistor and diode are neglected, the output voltage will be

$$V_{out} = V_{in} \frac{t_{on}}{T}$$

and it is independent of the load current. It is obvious from the equation that changes in input voltage can be compensated for by varying the duty cycle of the switched waveform. This is what is done in a switching regulator.

4.14 Figure 4.2 shows a self-oscillating switching regulator which produces this duty-cycle control. A reference voltage, V_{ref}, equal to the desired output voltage, is supplied to one input of an operation amplifier, A. The operational amplifier, in turn, drives the switch transistor. The resistive divider, arranged such that R_1 & R_2, provides a slight amount of positive feedback at high frequencies to make the circuit oscillate. At lower frequencies where the attenuation of the LC filter is less than the attenuation of the resistive divider, there is a net negative feedback to the inverting input of the operational amplifier.

4.15 In operation, when the circuit is first turned on, the output voltage is less than the reference voltage so the switch transistor is turned on. When this happens, current flow through R_1 raises the volt-

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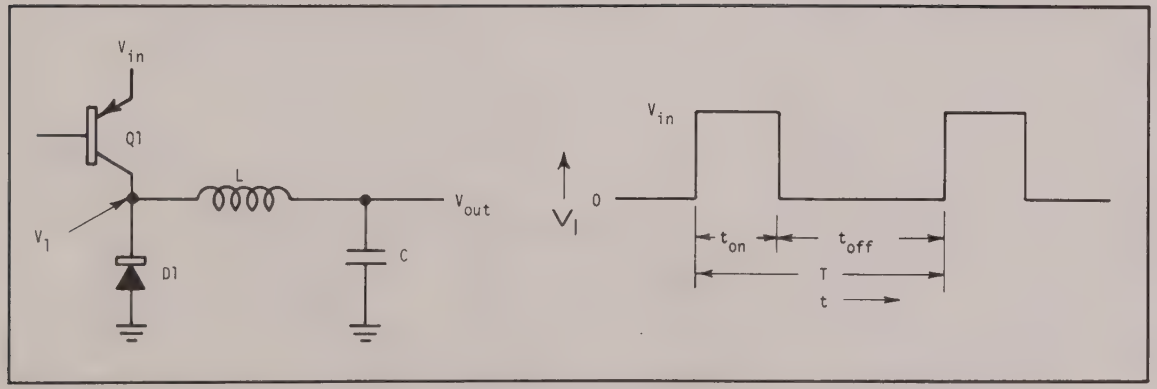

FIGURE 4.1 SWITCHING CIRCUIT FOR VOLTAGE CONVERSION

age on the non-inverting input of the operational amplifier slightly above the reference voltage. The circuit will remain switched on until the output rises to this voltage. The amplifier now goes into the active region, causing the switch to turn off. At this point, the reference voltage seen by the amplifier is *lowered* by feedback through R_1, and the circuit will stay off until the output voltage drops to this lower voltage. Hence, the output voltage oscillates about the reference voltage. The amplitude of this oscillation (or the output ripple) is nearly equal to the voltage fed back through R_1 to R_2 and can be made quite small.

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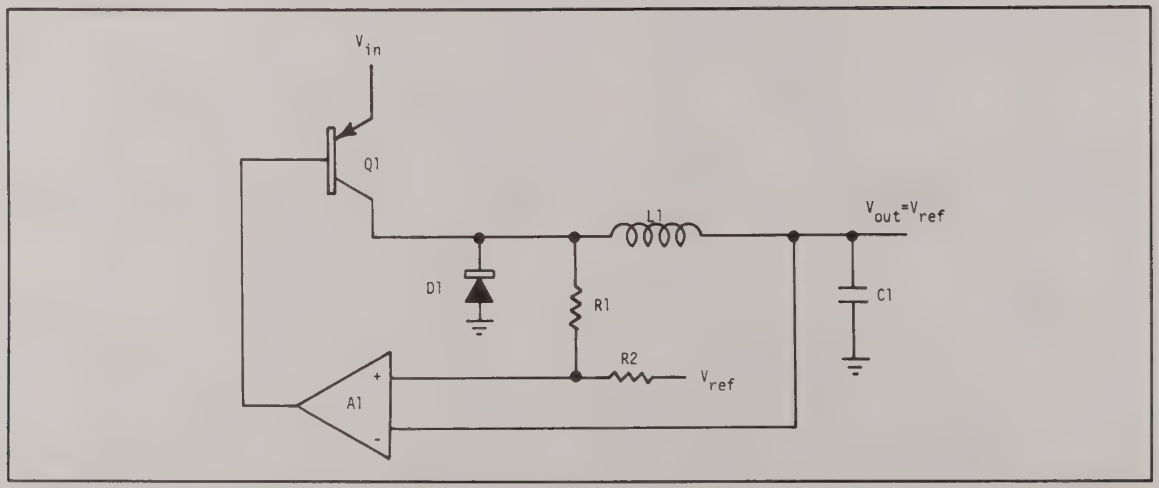

FIGURE 4.2 SELF-OSCILLATING SWITCHING REGULATOR

4.16 The voltage reference and the operational amplifier are both included in an IC which is a MC 1723 CL.

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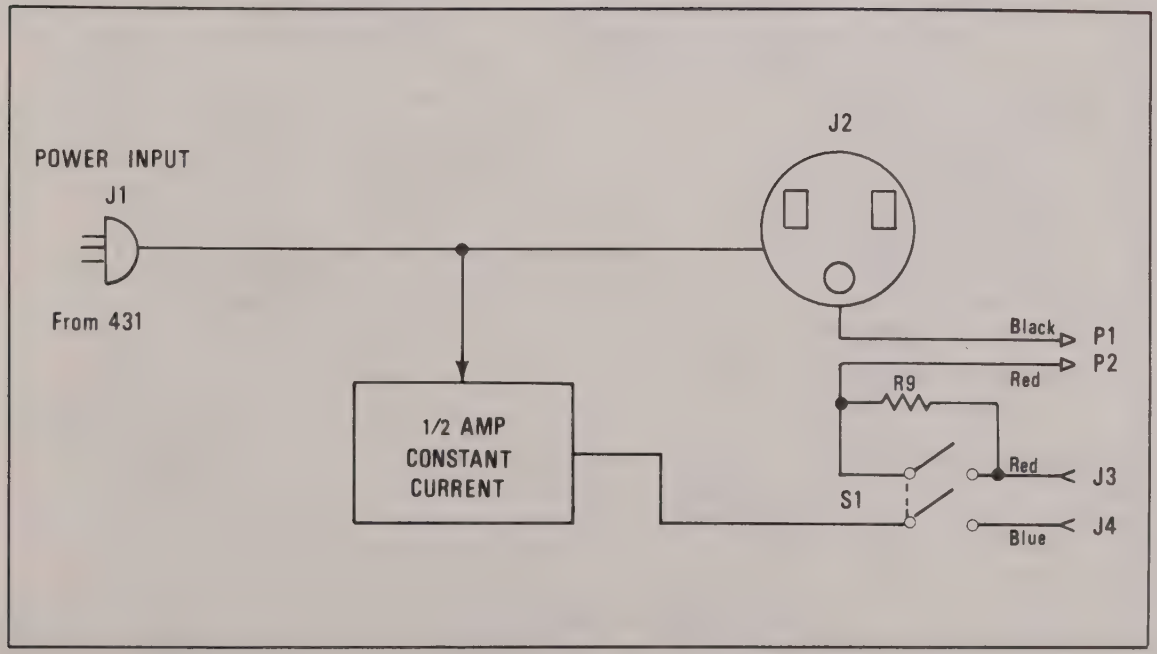

FIGURE 4.3 BLOCK DIAGRAM

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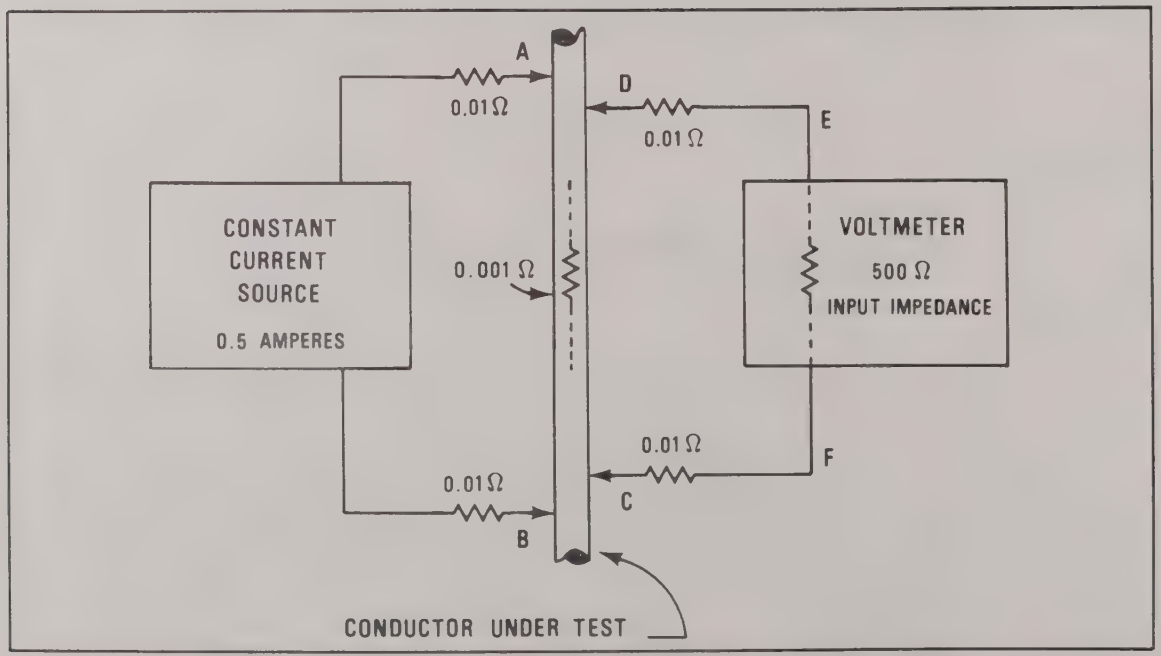

FIGURE 4.4 DIAGRAM OF FOUR-TERMINAL RESISTANCE MEASUREMENT

4.17 ■ THEORY OF THE FOUR-TERMINAL RESISTANCE MEASUREMENT

4.18 In order to measure the resistance of a given conductive pathway with great precision it is necessary to make the measurement independently of the resistance of the measuring equipment. Typically, resistance measurements are made by introducing a voltage across the conductor and then measuring the current going through it. In the precision measurement the reverse is done. A constant current is passed through the conductor and then the voltage imposed on the conductor is measured to determine the resistance. In Figure 4.4, which illustrates the test, the three separate components are clearly identified. First, the conductor under test; second, the constant current source and third, the voltmeter.

4.19 The current circuit includes the current source, the contacts to the conductor and the conductor itself. Assume that all wires in the system have their resistance concentrated in one point for the purposes of explanation, excluding of course, the conductor under test. The resistance of the current circuit then includes the resistance of the conductor under test (0.001 ohms) and the resistance of each of the contacts with that conductor (0.01 ohms each) for a total resistance of 0.021 ohms. The voltage generated by the constant current source to drive 0.5 amperes through the circuit is 10.5 millivolts (0.021 ohms X 0.5 amps). If this voltage were to be used to determine the circuit resistance, the value of resistance would be more than 20 times too large since the conductor has a resistance of 1 milliohm and the circuit would measure 21 milliohms.

4.20 By adding another set of connections (thus making four terminals instead of just two) and measuring the voltage across these additional terminals we avoid involving the connections (and the voltage drop) at A and B in the measurement. By connecting the voltmeter at points C and D, a voltage measurement can be made of the voltage at the conductor alone. Since the voltmeter is a high-impedance device in comparison to the test resistance, very little current flows through points C and D to

the voltmeter and the reading made is truly representative of the voltage on the conductor. (The voltmeter in this case is the 431 Safety Analyzer which has a 500Ω input impedance). The *load error* using the Millidapter is the measured resistance divided by the voltmeter circuit resistance or:

$$\frac{0.001\,\Omega}{500.02\,\Omega} = 0.000002$$

Therefore, introducing the voltmeter into the circuit does not cause any significant alternation of the circuit or the current flowing through the conductor under test. The voltage measured by the voltmeter is the voltage between points E and F while the voltage of interest is the voltage between points C and D. The difference between the two is due to the contact resistance at points C and D. The *series resistance error* due to these contacts is the contact resistance divided by the total voltmeter circuit resistance:

$$\frac{0.02\,\Omega}{500.02\,\Omega} = 0.00004$$

This error is also insignificant. Essentially the voltage measured by the voltmeter is the voltage between points C and D, independent of their contact resistance. Since the current is constant, it requires only scale conversion to read the meter directly in ohms of conductor resistance.

NOTE

The Safety Analyzer when used in the current mode, as illustrated above, is employed as a voltmeter having an input impedance of 500 ohms. Full scale sensitivity would then be 500 times the indicated current or 5 millivolts on the 10 microamp range, 50 millivolts on the 100 microamp range, and 500 millivolts on the 500 microamp range.

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performance check

5.1 ■ **GENERAL**

5.2 This section contains information for making a performance check on the Millidapter.

5.3 The Millidapter is all solid state and does not need periodic maintenance except for cleaning. The performance check should be made at least every six months.

5.4 ■ **PERFORMANCE CHECK**

5.5 The purpose of the performance check is to indicate whether or not the Millidapter is operating within the specifications listed in Table 1-1.

5.6 The performance check can be used as a part of an incoming quality assurance inspection, as a periodic operational test, or as a calibration check.

5.7 Measurements are made with a digital multimeter connected to the back of the Millidapter at the blue connector marked SOURCE. The other connection is to the ground pin receptacle on top of the Millidapter.

5.8 Connect the Millidapter to a properly operating Model 431 Safety Analyzer. Set the Millidapter function switch to MILLIOHMS.

5.9 ■ **SOURCE VOLTAGE**

5.10 Measure the D.C. voltage of the source as per 5.7 above. The voltage measured is the open loop voltage and should be 1.1 volts D.C. or greater.

5.11 ■ **SOURCE CURRENT**

5.12 Measure the D.C. source current as per 5.7 above. The current should be 0.500 amperes ± ½% (0.0025 amperes).

5.13 If the current is outside the specified range, adjust R3 on the circuit board to put the current in the proper range.

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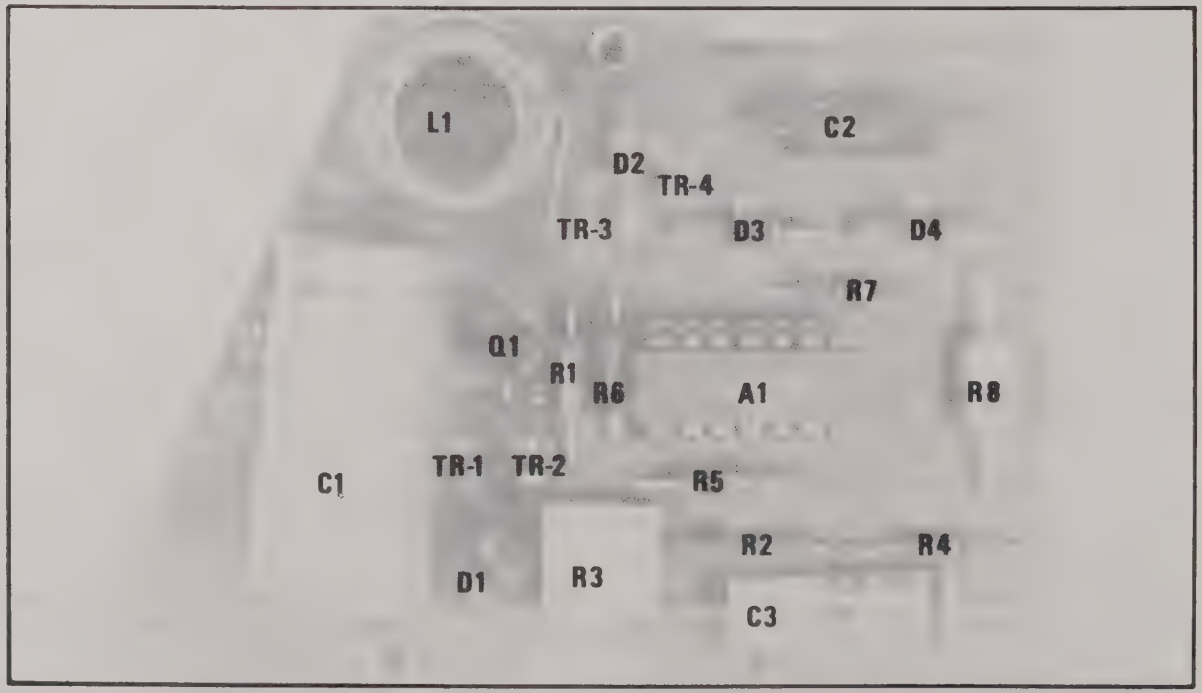

FIGURE 5.1 MAIN P.C. BOARD COMPONENT LOCATION

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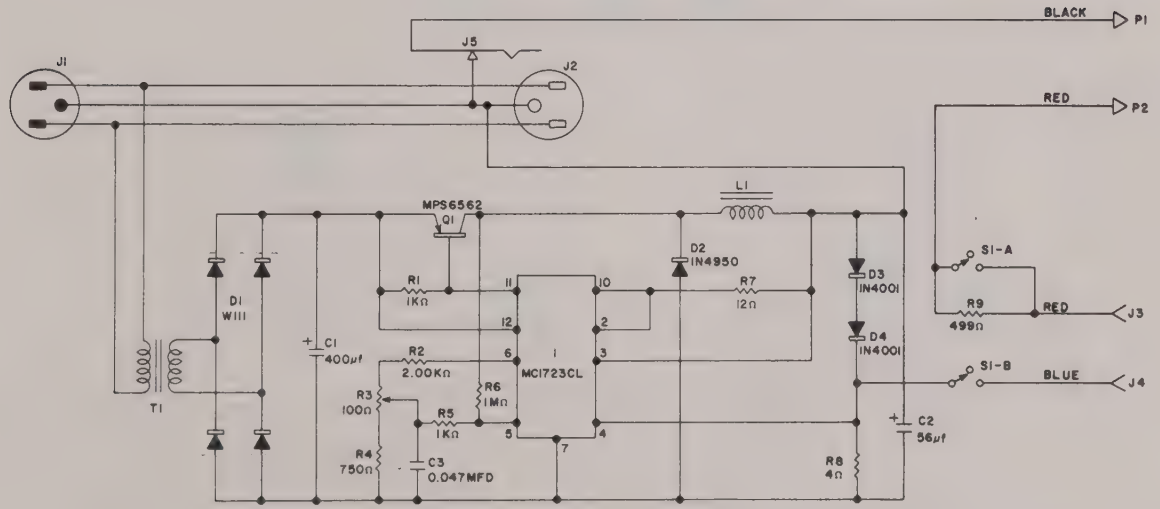

MILLIDAPTER, model 3102 SCHEMATIC

FIGURE 5.2 SCHEMATIC OF CURRENT SOURCE

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ABBREVIATIONS

AMP	=	*Ampere(s)*	*Q*	=	*Transistor*
D	=	*Diode*	*R*	=	*Resistor*
DC	=	*Direct Current*	*S*	=	*Switch*
J	=	*Jack*	*T*	=	*Transformer*
K	=	*Kilo, 1000*	*μf*	=	*Microfarad*
L	=	*Inductor*	*V*	=	*Volt*
LC	=	*Inductor Capacitor*	*W*	=	*Watt*
M	=	*Mega 10^6*	*Ω*	=	*Ohm*
P	=	*Plug*			

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replaceable parts

6.1 ■ INTRODUCTION

6.2 This section contains information for ordering replacement parts for the Model 3102 Millidapter.

6.3 Table 6-1 lists replaceable parts in alpha-numerical order to their subassembly and circuit symbols. Detailed information on a part used more than once in an assembly is listed opposite the first circuit symbol applying to the part in that assembly. Other circuit symbols applying to the same part in an assembly refer to the initial symbol. Detailed information includes the following:

1) ASSEMBLY
2) CIRCUIT SYMBOL
3) FULL DESCRIPTION OF PART
4) MANUFACTURER OF PART
5) MANUFACTURER'S PART NUMBER
6) TOTAL QUANTITY USED IN THE EQUIPMENT

6.4 ■ ORDERING INFORMATION

6.5 Most of the parts listed in the parts list can be secured from local electronic parts houses. If this is not feasible or a part needs replacing that is not listed, address order or inquiry to:

CUSTOMER SERVICE
NEURODYNE-DEMPSEY, INC.
P O BOX 1925
CARSON CITY, NEVADA 89701
[702] 883-3400

Specify the following information for each part:

1) MODEL AND COMPLETE SERIAL NUMBER ON INSTRUMENT
2) ASSEMBLY
3) CIRCUIT SYMBOL
4) MANUFACTURER OF PART
5) MANUFACTURER'S PART NUMBER
6) DESCRIPTION

6.6 To order a part not listed, give a description of the part and include its function and location.

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TABLE 6-1 REPLACEABLE PARTS FOR 3102

REF SYM	DESCRIPTION	MFG	MFG NO	TQ
	PC Board Assembly	R.H.Dempsey	100266	1
A1	Voltage Regulator	Motorola	MC1723CL	1
C1	Capacitor, Electrolytic 400µf 25V DC	Amperex	C437AR/F400	1
C2	Capacitor, Electrolytic 56µf 6V DC	Kemet	T310-C566K006	1
C3	Capacitor, Mylar 0.047MFD 100V DC	Cornell-Dubilier	MFP-1S47	1
D1	Diode, Bridge 1ADC 50PIV	Varo	W111	1
D2	Diode		1N4950	1
D3	Diode		1N4001	2
D4	Same as D3			
J1	Jack, Power	R.H.Dempsey	100271-1	1
J2	Jack, Power	R.H.Dempsey	100271-2	1
J3	Jack, Banana Red	Smith	205-102	1
J4	Jack, Banana Blue	Smith	205-105	1

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TABLE 6-1 REPLACEABLE PARTS (continued)

REF SYM	DESCRIPTION	MFG	MFG NO	TQ
L1	Inductor	R.H.Dempsey	100272	1
Q1	Transistor	Motorola	MPS6562	1
R1	Resistor, Composition 1KΩ ±5% 1/4W			2
R2	Resistor, M.F. 2.00KΩ ±1% 1/8W			1
R3	Resistor, Variable 100Ω	Helipot	72 PMR-100	1
R4	Resistor, M.F. 750Ω ±1% 1/8W			1
R5	Same as R1			
R6	Resistor, Composition 1MΩ ±5% 1/4W			1
R7	Resistor, Composition 12Ω ±5% 1/4W			1
R8	Resistor, W.W. 4Ω ±5% 2W	Sprague	240E4R05	1
R9	Resistor, M.F. 499Ω ±1% 3/4W	Corning	NA70	1
	IC Socket	Waldom	05-30-0007	2
	PC Terminal	AMP	60824-1	4
	PC Terminal Receptacle	AMP	60804-2	4

r.h.dempsey mfg.
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TABLE 6-1 REPLACEABLE PARTS (continued)

REF SYM	DESCRIPTION	MFG	MFG	TQ
S1	Switch, Slide	Switchcraft	46206-LR	1
T1	Transformer	R.H.Dempsey	100270	1
	Contact, Large	R.H.Dempsey	100268	1
	Contact, Small	R.H.Dempsey	100269	1
	Test Lead T3114-6	R.H.Dempsey	100256	1
	Test Lead T3115-12	R.H.Dempsey	100274	1

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notes